

Fig. A4.10

- T = engine thrust.
- L = total wing lift plus fuselage lift.
- D = total airplane drag.
- Ma = moment of L and D with reference to wing a.c. (aerodynamic center)
- W = weight of airplane.
- IL = inertia force normal to flight path.
- ID = inertia force parallel to flight path.
- Im = rotation inertia moment.
- E = tail load normal to flight path.

For a horizontal constant velocity flight condition, the inertia forces I_L , I_D , and I_m would be zero. For an accelerated flight condition involving translation but not angular acceleration about its own c.g. axis, the inertia moment I_m would be zero, but I_L and I_D would have values.

Equations of Equilibrium For Steady Flight.

From Fig. A4.10 we can write:-

$$\sum F_x = 0, \quad D + W \sin \theta - T \cos \beta = 0$$

$$\sum F_y = 0, \quad L - W \cos \theta + T \sin \beta - E = 0$$

$$\sum M_y = 0, \quad -M_a - L a - D b + T c \cos \beta + E e = 0$$

Equations of Equilibrium in Accelerated Flight.

$$\sum F_x = 0, \quad D - W \sin \theta - T \cos \beta - I_D = 0$$

$$\sum F_y = 0, \quad L - W \cos \theta + T \sin \beta - I_L - E = 0$$

$$\sum M_y = 0, \quad -M_a - L a - D b + T c \cos \beta + E e + I_m = 0$$

Signs used: { Forces - Plus is up and toward tail.
Moment - Clockwise is positive.
Distances from c.g. to force - Plus is up and toward tail.

A4.7 Load Factors.

The term load factor normally given the symbol (n) can be defined as the numerical multiplier by which the forces on the airplane in steady flight are multiplied to obtain a static force system of forces equivalent to the dynamic force system acting during the acceleration of the airplane. Fig. A4.11 illustrates

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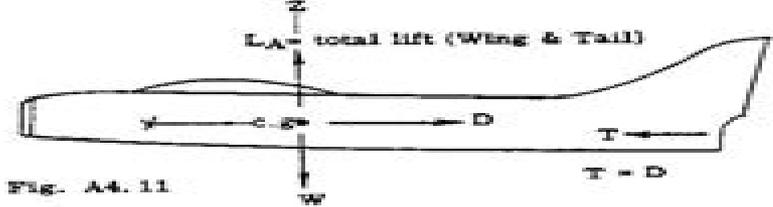


Fig. A4.11

forces in steady horizontal flight. L represents the total airplane lift (wing plus tail). Therefore $L = W$. Now assume the airplane is accelerated upward along the Z axis. Fig. A4.12 shows the additional inertia force $W a_z/g$ acting downward, or opposite to the direction of acceleration. The total airplane lift L for the



Fig. A4.12

unaccelerated condition in Fig. A4.11 must be multiplied by a load factor n_z to produce static equilibrium in the Z direction.

Thus, $n_z L - W - \frac{W}{g} a_z = 0$

Since $L = W$

Hence $n_z = 1 + \frac{a_z}{g}$

An airplane can of course be accelerated along the X axis as well as the Z axis. Thus in Fig. A4.13 the magnitude of the engine thrust T is greater than the airplane Drag D, which

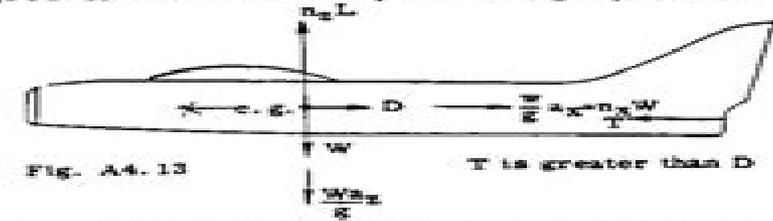


Fig. A4.13

causes the airplane to accelerate forward. It is convenient to express the inertia force in the direction in terms of the load factor n_x and the

Analysis Design Of Flight Vehicle Structures Solution

Zhe Xu



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